IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

U.S. Patent Application No.: 09/998,469	Group Art Unit: 2814
Filing Date: November 29, 2001	Examiner: Peralta, Ginette
For: Barrier Layers For Protecting Metal Oxides From Hydrogen Degradation	Docket No.: 13176.403
Applicants: Solayappan et al.	Confirmation No.: 5686
	Attachment to Paper No.: 9

CERTIFICATE OF TRANSMISSION UNDER 37 CFR 1.8

I hereby certify that this correspondence, along with all papers referred to as being transmitted, are being facsimile transmitted to the Patent and Trademark Office Fax No. (703) 308-7724.

September 16, 2003 — Date

Elaine C. VonSpreckelsen — Elaine C. VonSpreckelsen

DECLARATION OF LARRY D. McMILLAN

I, Larry D. McMillan, hereby declare:

1. I am President and CEO of Symetrix Corporation at 5055 Mark Dabling Boulevard, Colorado Springs, Colorado, where I am involved in directing various research and business activities, which include integrated circuit manufacturing process development. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true.

2. I have worked for over thirty years as an integrated circuit process engineer. I have published more than a hundred papers and presentations on the subject of integrated circuit process engineering and have more than thirty issued patents in the field. A copy of my curriculum vitae with a partial list of my papers and patents is attached hereto.

3. Symetrix Corporation (Symetrix) is the assignee of the above-designated patent application (hereinafter, "the application").

4. I submit this Declaration to present to the Examiner, in an authenticated manner, facts concerning the relevance of the references cited in the Office Action dated June 16, 2003 (hereinafter, "the Office Action").

5. I have read the present claims of the application, the Office Action, and the

references cited by the Examiner, particularly, U.S. Patent Application Publication No. U.S. 2002/0038402 A1, published March 28, 2002, naming Kanaya (hereinafter "Kanaya"), and U.S. Patent No. 6,351,004 B1, Issued February 26, 2002 to Shimada et al.. (hereinafter "Shimada").

6. The Shimada reference does not say that second insulating layer 8 prevents oxidation of source 3 and drain 4.

7. It Is not inherently clear that an oxide second insulating layer 8 as disclosed in Shimada would protect against oxidation.

8. Shimada does not mention or discuss using second insulating layer 8 as a hydrogen barrier layer.

9. Even if second insulating layer 8 of Shimada were disclosed as a layer to protect against oxidation, there is no suggestion in Shimada or in the art in general that an element that protects against oxidation protects against hydrogen diffusion.

10. Metal-oxide hydrogen diffusion barrier layers comprising a material such as strontium tantalate, bismuth tantalate, and tantalum oxide, as claimed In Independent claims 1 and 28 of the application, are generally electrically insulating.

11. Metal-oxide hydrogen diffusion barrier layers, such as strontium tantalate, bismuth tantalate, and tantalum oxide as claimed in independent claims 1 and 28 of the application, inhibit hydrogen diffusion by "gettering" hydrogen atoms, which reduce the functional oxides. Such metal-oxide materials do not protect well against oxidation.

12. Permittivity is directly related to the dielectric constant of a material by the equation

$$\varepsilon = K\varepsilon_o,$$

where ε is permittivity, K is a relative dielectric constant, and ε_o is the permittivity of a vacuum.

13. It is well-known in the art that the insulating properties, the dielectric constant and thereby the permittivity of a metal oxide material, such as $SrTa_2O_6$,

decrease when the oxide is partially reduced by hydrogen, resulting in a non-oxide material replacing some of the oxide material.

14. It is also well-known in the art that a layer of metal oxide, such as $SrTa_2O_6$, that functions as a hydrogen diffusion barrier functions by "gettering" hydrogen atoms as they diffuse into the metal-oxide layer.

15. The hydrogen atoms reduce some of the oxygen atoms of the oxide material and thereby decrease the insulating characteristic and permittivity of the layer.

16. Accordingly, an insulating metal oxide, such as strontium tantalate ($SrTa_2O_6$), is useful in an integrated circuit either as a hydrogen barrier (as disclosed in the present application) or alternatively as an electrically insulating layer having high permittivity, but not as both.

17. If an insulating layer of metal oxide $SrTa_2O_6$ were used in an integrated circuit as a hydrogen diffusion barrier layer subjected to reductive process conditions involving reactive hydrogen atoms, some of the oxide would be reduced to a different, non-oxide compound and the resulting material would be unsatisfactory for its intended purpose of being a high-permittivity dielectric insulator.

18. The principle of operation of a metal oxide hydrogen barrier layer in accordance with the invention, such as strontium tantalate, is that some of the oxide is virtually sacrificed in its reaction with reactive hydrogen atoms during fabrication, and thereby has no functional role during actual operation of the integrated circuit.

19. In contrast, the principle of operation of a metal-oxide second insulating layer 8 in the Shimada reference is to function as a metal-oxide high-permittivity dielectric during actual operation of the integrated circuit.

20. Therefore, if second insulating layer 8 of Shimada were modified to serve as a hydrogen barrier layer in accordance with the present invention, at least a portion of the metal oxide would be reduced during fabrication processes, thereby changing the principle of operation of metal-oxide second insulating layer 8 of Shimada.

21. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements

and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. §1001, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Sept. 11, 2003
Date

Larry D. McMillan

Larry D. McMillan

EDUCATION

Ph.D. (Candidate)	University of Colorado at Colorado Springs
M.S.E.E.	Arizona State University, 1972
B.S.	Aquinas College, 1965 (physics and mathematics)

Michigan Technological University, 1986-1993
Adjunct Professor

EXPERIENCE

1988-Present President and CEO
Symetrix Corporation

Corporate Management. Ferroelectric and other proprietary materials research and development, process and device development, program management and planning.

1984-1988 Ramtron Corporation
Vice President (R&D) and Corporate Founder

Member, Ramtron Board of Directors. Research and development of ferroelectric memory devices and integrated circuits. Primary investigations of phase three potassium nitrate and other ferroelectric materials.

1982-1984 Honeywell, Inc.
MOS Operations Manager

All MOS operations including wafer fabrication, maintenance, device engineering, process engineering, product engineering, test engineering, CAP/CAM, production testing and new process development. Member of Key Management Group (Corporate Level).

Manager, MOS Advanced Development

CAP/CAM development, CMOS process development, CCD TCL sensor process development, process transfers and long range planning activities. Developed and taught Operator and Technician Level IC Processing course (Honeywell Certificate Program).

MOS Process Engineering Manager

MOS production process engineering, maintenance, CCD process transfer from R&D to production, 3" to 4" wafer conversion, and advanced silicon gate MOS process development.

1980-1982 Stephenson Western, Inc.
Vice President

Engineering Consultant to the semiconductor industry. Computer modeling, fab design, UPDI water system design, process equipment selection, EPA regulations and hazardous chemical disposal. (Customer base included: Motorola, General Electric, Monolithic Memories, Fairchild, Signetics, Storage Technology, Intel and Mitel. (The firm was purchased by The Thomas Group.)

1979-1980 Storage Technology Corporation
Vice President and General Manager of Microtechnology Operations

Organized, staffed, designed and facilitized startup of semiconductor and thin film head and thin film media R&D and production facility.

1977-1979 National Cash Register (NCR) Corporation
Director of Engineering

All research, development and program management activities at the Colorado Springs NCR Integrated Circuit facility.

1976-1977 American Microsystems, Inc.
Manager, CMOS Process Engineering

All aspects of silicon gate CMOS process engineering, including process control and process development. VMOS and UMOS process development and transfer of NMOS process to Pocatello, Idaho facility. Developed and taught Operator and Technician Level Mathematics course.

1966-1976 Motorola, Inc.
Manager, Device Engineering (1975-1976)

Silicon gate NMOS fab device engineering and production process control. Established LPCVD silicon nitride and poly silicon as production processes in Austin, Texas facility.

Staff Scientist, Advanced Product R & D Labs (1973-1975)

Process development of 4K and 16K NMOS RAMS. Multi-level metal MOS development, spin-on metallic oxide development, and LPCVD poly silicon and silicon nitride development.

Manager, Linear IC Wafer Engineering (1973-1970)
Expanded Mesa, Arizona linear IC manufacturing capability from 2,000-2" wafers to 14,000-3" wafers per week. Linear device engineering, specification control, process control, wafer process engineering, linear process development, HIREL pilot line and wafer test. Developed and taught Engineering Level Process Engineering Classes (Motorola Certificate Program).

Engineering Manager, Product Engineering Liaison (1969-1970)
Safeguard Missile Program (secret). Beam lead processing.

Engineer, Motorola Advanced Pilot Line (1967-1969)
Photoresist, metalization, product development.

Engineer, Motorola Training Program (1966-1967)
MOS process development, C-V analysis, multi-layer metal, Epi, materials research, packaging.

Publications and Presentations

V. Joshi, J. D. Cuchiaro, L.D. McMillan and C.A. Paz de Araujo, "Stoichiometry Control of Spin-On SrBi2Ta2O9 Ferroelectric Thin Films", (abstract for a presentation)

T. Mihara, H. Yoshimori, H. Watanabe, T.Itoh, "Superior Electrical Characteristics of Bi-layered Perovskite Thin Film and Comparison with PZT",

J.F. Scott, C.A. Paz de Araujo and L.D. McMillan, "Retention in Thin-Film Ferroelectric Memories",

H. Yoshimori, H. Watanabe, T. Mihara, H. Nakano, S. Hiraide, C.A. Paz de Araujo, & L.D. McMillan, "Process Integration for Y1 Capacitors with CMOS Devices",

L.D. McMillan, "LSMCD: Technology Status and Recent Results",

Y. Oishi, M. Azuma, S. Hayashi, L.D. McMillan, & C.A. Paz de Araujo, "Electrical Characteristics of Mn doped Thin Film BST",

J.W. Gregory and C.A. Paz de Araujo, L.D. McMillan, T. L. Roberts and V.J. McMillan, "Device Characterization of Barium Magnesium Tetrafluorine on Silicon Dioxide",

L. D. McMillan, "MOS C-V Techniques for IC Process Control", *Solid State Technology*, pp 605-610, September 1972

L. D. McMillan, "Semiconductor Process Newsletters", *Stephenson Western, Inc.*, (Published Monthly, 1980-1982)

L. D. McMillan and F. Stephenson, "Computer Model Analysis of Process Wafer Requirements and Associated Costs", *Microelectronics Measurement Technology Seminar*, San Jose, CA (18 March 1981).

C. A. Paz de Araujo, L. D. McMillan, and G. Rohrer, "Development of Advanced Non-Volatile Thin Film Ferroelectric Memories", UCCS Proposal, Funded, April 1984.

L. D. McMillan, "Rampac Development Program Status Review", *International Technology Symposium*, Sydney, Australia, 28 October 1985.

L. D. McMillan, "A New Ferroelectric Non-Volatile Memory", *U.S. government Non-Volatile Memory Technology Review Conference*, Baltimore, MD 29 august 1985.

L. D. McMillan, "Cubic Integration", Ramtron Technical Disclosure Level 2, *File No. 6, Document No. 018*, (1985)

C. A. Paz de Araujo, L. D. McMillan, R. B. Godfrey, and G. Rohrer, "High Speed (<100 ns) Non-Volatile Memory Using Ferroelectric Switching", *4th Australian Microelectronics Conference*, Sydney, Australia, May, 1985.

J. F. Scott, R. B. Godfrey, C. A. Paz de Araujo, L. D. McMillan, H. B. Meadows, and M. Golabi, "Device Characteristics of Ferroelectric Ceramic KNO_3 Thin-Film raw Memories", Proceedings of the *Sixth IEEE International Symposium on Applications of Ferroelectrics*, Lehigh University, Bethlehem, PA, June 8-11, 1986.

C. A. Paz de Araujo, J. F. Scott, R. B. Godfrey, and L. D. McMillan, "Analysis of Switching Transients in KNO_3 Ferroelectric Memories", *Applied Physics Letter*, Vol. 18, No. 21, May 26, 1986.

R. B. Godfrey, J. F. Scott, H. B. Meadows, M. Golabi, C. A. Paz de Araujo, and L. D. McMillan, "Analysis of Electrical Switching in Sub-Micron KNO_3 Thin-Films", *Ferroelectrics Letters*, Vol. 5, pp. 167-172, 1986.

N. Solayappan, A. K. Kulkarni, G. Rohrer, and L. D. McMillan, "A New Technique For Characterizing Thin Film Ferroelectric Memory Devices", *34th National Symposium of the American Vacuum Society*, Anahelm, CA, 2 November 1987.

A. K. Kulkarni, N. Solayappan, G. Rohrer, and L. D. McMillan, "Electrical Properties of KNO_3 Thin Film Memory Devices", *International Conference On Thin Films*, New Deli, India, 7 December 1987.

J. F. Scott, M. Zhang, R. B. Godfrey, C. A. Paz de Araujo, and L. D. McMillan, "Raman Spectroscopy of Submicron KNO_3 Films", *Physical Review B. Condensed Matter*, Vol. 35, No. 8, pp. 4044-4051, 15 March 1987.

A. K. Kulkarni, G. Rohrer, L. D. McMillan, and Adams, "Dependence Of The Electrical Properties Of KNO_3 Memory Devices on Fabrication And Processing Parameters", *The 35th National Symposium Of The American Vacuum Society*, Atlanta, GA, October 1988.

A. K. Kulkarni, G. Rohrer, L. D. McMillan, and Adams, "Structural Properties Of Thin Film Memory Devices", *15th International Conference On Metallurgical Coatings*, San Diego, CA, April, 1988.

L. D. McMillan, "Ferroelectric Materials and Deposition Techniques", *Joint Industry and Government Conference on Ferroelectrics*, Colorado Springs, CO, September 13-14, 1988.

G. Rohrer, N. Solayappan, L. D. McMillan, and A. K. Kulkarni, "A New Technique For Characterization Of Thin-Film Ferroelectric Memory Devices", *Journal of Vacuum Science & Technology*, A 6(3), May/June 1988.

L. D. McMillan, "New Space Age Electronic Materials", *Seminar On Electronic Materials*, Michigan Technological University, Houghton, MI, August 24, 1988.

L. D. McMillan, "Ferroelectric Material Developments", *Department of Defense Advisory Group on Electron Devices*, Boulder, CO, 23 June, 1988.

J. F. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Switching Kinetics of Lead Zirconate Titanate Sub-Micron Thin-Film Memories", presented at the *First European Conference on Applications of Polar Dielectrics, International Symposium on Applications of Ferroelectrics*, Zurich, Switzerland, August 1988.

J. F. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Switching Kinetics of Lead Zirconate Titanate Sub-Micron thin-Film Memories", *Ferroelectrics*, September, 1988.

J. F. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Switching Kinetics of Lead Zirconate Titanate Sub-Micron Thin-Film Memories", *Ferroelectrics*, Vol. 93, pp. 31-36, 1989.

J. F. Scott, C.A. Paz de Araujo, and L. D. McMillan, "Ferroelectric Memory Applications", invited paper presented at the *IEEE 1989 Ultrasonic Symposium & Short Courses*, Montreal, Canada, pp. 299-308, October 1989.

J. F. Scott, C. A. Paz de Araujo, H. B. Meadows, and L. D. McMillan, "Radiation Effects on Ferroelectric Thin-Film Memories: Retention Failure Mechanisms", *Journal of Applied Physics*, Vol. 66, No. 3, pp. 1444-1453, 1 August 1989.

J. Free, "Memory Chips that Don't Forget", Popular Science, pp. 86-88, April 1990. (consultant)

J. F. Scott, C. A. Paz de Araujo, B. M. Melnick, and L. D. McMillan, "Physics and Engineering of Ferroelectric Memories", presented at *the Fifth U. S. – Japan Seminar on Dielectric and Piezoelectric Ceramics*, Kyoto, Japan, December 11, 1990.

J. F. Scott, C. A. Paz de Araujo, and L. D. McMillan, "Electronic Ceramic Memories", presented at *the International Conference on Electronic Ceramics-Production and Properties*, Riga, Latvia, April 30, 1990.

B. M. Melnick, J. D. Cuchiaro, L. D. McMillan, C. A. Paz de Araujo, and J. F. Scott, "Process Optimization and Characterization of Device Worthy Sol-Gel Based PZT for Ferroelectric Memories", *Ferroelectrics*, Vol. 112, pp. 241-256, 1990.

C. A. Paz de Araujo, L. D. McMillan, B. M. Melnick, J. D. Cuchiaro, and J. F. Scott, "Ferroelectric Memories", *Ferroelectrics*, Vol. 104, pp. 241-256, 1990.

H. M. Duiker, P. D. Beale, J. F. Scott, C. A. Paz de Araujo, B. M. Melnick, J. D. Cuchiaro, and L. D. McMillan, "Fatigue and Switching in Ferroelectric Memories: Theory and Experiment", *Journal of Applied Physics*, Vol. 68, No. 11, pp. 5783-5791, 1 December 1990.

A. K. Kulkami, g. Rohrer, N. Solayappan, and L. D. McMillan, "A Circuit Model for a Thin Film Ferroelectric Memory Device", *Ferroelectrics*, Vol. 116, pp. 95-106, 1991.

B. M. Melnick, C. A. Paz de Araujo, L. D. McMillan, D. A. Carver, and J. F. Scott, "Recent Results on Switching, Fatigue and Electrical Characterization of Sol-Get Based PZT Capacitors", *Ferroelectrics,* Vol. 116, pp. 79-93, 1991.

J. F. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Ferroelectric Memories: A comparison with Other High-Speed Digital Devices", *Ferroelectrics*, Vol. 116, pp. 147-155, 1991.

J. F. Scott, C. A. Paz de Araujo, B. M. Melnick, L. D. McMillan, and R. Zuleeg, "Quantitative Measurement of Space-Charge Effects in Lead Zirconate-Titanate Memories", *Journal of Applied Physics*, Vol. 69, No. 11, 1 June 1991.

J. F. Scott, C. A. Paz de Araujo, B. M. Melnick, L. D. McMillan, and R. Zuleeg, "Quantitative Measurement of Space-Charge Effects in Lead Zirconate-Titanate Memories", *Journal of Applied Physics*, Vol. 70, No. 1, pp. 382-388, 1 July 1991.

L. D. McMillan, C. A. Paz de Araujo, M. Scott, "High Dielectric Constant Materials and Processes for Advanced Multi-Layered PC Boards" *A Consultancy Report for Storage Technology Corporation,* May 30, 1991.

E. Fujii, Y. Uemoto, S. Hayashi, T. Nasu, Y. Shimada, A. Matsuda, M. Kibe, M. Azuma, T. Otsuki, G. Kano, M. Scott, L. D. McMillan, and C. A. Paz de Araujo, "ULSI DRAM Technology with $Ba_{0.7}Sr_{0.3}TiO_3$ Film of 1.3nm Equivalent SiO_2 Thickness and 10^{-9} A/cm^2 Leakage Current, presented at *International Electron Devices Meeting,* San Francisco, CA, December 1992.

L. D. McMillan, C. A. Paz de Araujo, T. Roberts, J. d. Cuchiaro, M. C. Scott, and J. F. Scott, "Liquid Source CVD", *Integrated Ferroelectrics*, Vol. 2, pp. 351-359, 1992.

C. A. Paz de Araujo, L. D. McMillan, and J. F. Scott, "Processing of Ferroelectric Memories", *Materials Resource Society Symposium Proceedings*, Vol. 230, 1992.

J. F. Scott, C. A. Paz de Araujo, and L. D. McMillan, "Anomalous Switching Kinetics in Ferroelectric Thin (<200nm) Films", presented at *International Conference on Domains*, Nantes, France, 1992. (*Ferroelectrics*, 1993, Vol. 140, pp. 219-223.)

J. F. Scott, M. Azuma, E. Fujii, t. Otsuki, G. Kano, M. C. Scott, C. A. Paz de Araujo, L. D. McMillan, and T. Roberts, "Microstructure-induced Schottky Barrier Effects in Barium Strontium Titanate (BST) Thin Films for 16 and 64 mbit DRAM Cells", presented at *International Symposium on Applications of Ferroelectrics*, South Carolina, August 1992.

J. F. Scott, C. A. Paz de Araujo, L. D. McMillan, H. Yoshimori, H. Watanabe, T. Mihara, M. Azuma, T. Ueda, D. Ueda, and G. Kano, "Ferroelectric Thin Films in Integrated Microelectronics Devices", presented at the *25th International Conference on Polar Dielectrics*, London, April 1992.

B. M. Melnick, J. F. Scott, C. A. Paz de Araujo, and L. D. McMillan, "Thickness Dependence of d.c. Leakage Current in Lead Zirconate-Titanate (PZT) Memories", *Ferroelectrics*, Vol. 135, pp. 163-168, 1992.

C. A. Paz de Araujo, R. Zuleeg, T. Mihara, H. Watanage, A. Carrico, L. D. McMillan, and J. F. Scott, "Statistical Theory of Fatigue in Ferroelectric Devices", *Integrated Ferroelectrics*, Vol. 1, pp. 305-322, 1992.

T. Mihara, H. Watanabe, H. Yoshimori, C. A. Paz de Araujo, B. M. Melnick, and L. D. McMillan, "Process Dependent Electrical Characteristics and Equivalent Circuit Model of Sol-Gel Based PZT Capacitors", *Integrated Ferroelectrics*, Vol. 1, pp. 269-291, 1992.

J. F. Scott, B. M. Melnick, C. A. Paz de Araujo, L. D. McMillan, and R. Zuleeg, "d.c. Leakage Currents in Ferroelectric Memories", *Integrated Ferroelectrics*, Vol. 1, pp. 323-331, 1992.

J. F. Scott, L. D. McMillan, and C. A. Paz de Araujo, M. Azuma, T. Ueda, T. Ueda, D. Ueda, and G. Kano, "High-e Films as SiO2 Replacements in ULSI Devices", *Specialists' Conference on Semiconductor Interfaces*, IEEE Invited Paper, San Diego, CA, December 1992.

J. F. Scott, C. A. Paz de Araujo, and L. D. McMillan, "Integrated Ferroelectrics", *Condensed Matter News*, Vol. 1, No. 3, pp. 16-20, 1992.

B. M. Melnick, M. C. Scott, C. A. Paz de Araujo, L. D. McMillan, and T. Mihara, "Anomalous Fatigue Behavior in Zn Doped PZT", *The Proceedings of the Fourth International Conference on Integrated Ferroelectrics,* Monterey, CA, p. 221, March 1992.

H. Yoshimori, H. Nakano, T. Mihara, H. Watanabe, C. A. Paz de Araujo, and L. D. McMillan, "A Low Density Ferroelectric RAM", *The Proceedings of the Fourth International conference on Integrated Ferroelectrics,* Monterey, CA, p 275, March 1992.

T. Mihara, H. Watanabe, C. A. Paz de Araujo, J. D. Cuchiaro, M. C. Scott, and L. D. McMillan, "Feasibility for Memory Devices and Electrical Characterization of Newly Developed Fatigue Free Capacitors", *The Proceedings of the Fourth International Conference on Integrated Ferroelectrics,* Monterey, CA, p 173, March 1992.

J. D. Cuchiaro, M. C. Scott, C. A. Paz de Araujo, T. Mihara, and L. D. McMillan, "Switching Kinetics of Ferroelectric Fatigue Free Material", presented at *Fourth International Conference on Integrated Ferroelectrics*, Monterey, CA, March 1992.

L. D. McMillan, J. F. Scott, C. A. Paz de Araujo, invited paper, "Liquid-Source CVD of Ferroelectric Thin-Film Memories", *39th National Symposium, American Vacuum Society*, November 9-13, 1992.

B. M. Melnick, L. D. McMillan, and C. A. Paz de Araujo, "The Effect of "Excess Pb-Based Layered Capacitor Structures" on the Fatigue Characteristics of Ferroelectric Memories", April 15, 1992.

L. D. McMillan, "Deposition of Barium Strontium Titanate and Strontium Titanate via Liquid Source Chemical Vapor Deposition", abstract, *The First International Workshop on the Application of Ferroelectric Materials, Korea Advanced Institute of Science and Technology*, Taejon, Korea, October 21, 1993, p.91.

J. F. Scott, B. M. Melnick, L. D. McMillan, C. A. Paz de Araujo, and M. Azuma, "Dielectric Breakdown in High-ε Films for ULSI DRAMS", *Ferroelectrics*, 1993, Vol. 150, pp. 209-218.

T. Mihara, H. Yoshimori, S. Hiraide, H. Watanabe, Y. Kuroda, T. Takahashi, H. Nakano, C. A. Paz de Araujo, L. D. McMillan, and Y. Ishibashi, "Studies of Integrated Ferroelectric Thin Film Capacitors for Nonvolatile Memory Application", presented at *5th International Symposium on Integrated Ferroelectrics*, Colorado Springs, CO, April 19-21, 1993.

T. Milara, H. Watanabe, H. Nakano, S. Hiraide, C. A. Paz de Araujo, and L. D. McMillan, "Process Integration for Y1 Capacitors with CMOS Devices", presented at the *5th International Symposium on Integrated Ferroelectrics*, Colorado Springs, CO, April 19-21-1993.

C. A. Paz de Araujo and L. D. McMillan, "A New Material for Non-volatile Memory, Which Can Rewrite More Than 102 times, Was Developed and Measured", *Nikkei Electronics*, May 24, 1993, pp. 94-100 (Japanese text).

M. Azuma, E. Fujii, Y. Uemoto, S. Hayashi, t. Nasu, Y. Shimada, A. Matsuda, M. Kibe, T. Otsuki, G. Kano, M. C. Scott, L. D. McMillan, and C. A. Paz de Araujo, "ULSI DRAM Technology with High Dielectric Constant Materials", presented *at 5th International Symposium on Integrated Ferroelectrics*, Colorado Springs, CO, April, 1993.

J. F. Scott, M. Azuma, C. Z. Paz de Araujo, L. D. McMillan, M. C. Scott, and T. Roberts, "Dielectric Breakdown in High e Films for ULSI DRAMS: II Barium-Strontium Titanate Ceramics", *Matsushita Electronics Corporation 1993 Annual Report*.

L. D. McMillan, "Deposition of Barium Strontium Titanate and Strontium Titanate via Liquid Source Chemical Vapor Deposition", *Integrated Ferroelectrics*, Vol. 00, pp. 000-000, 1994.

M. Huffman and L. D. McMillan, "Liquid Source Misted Chemical Deposition: Technology Status and Recent Results", presented at the *2nd Pacific Rim Conference on Ferroelectric Applications*, Melbourne, Australia, November, 1994.

L. D. McMillan, "Deposition of Barium Strontium Titanate and Strontium Titanate via Liquid Source Chemical Vapor Deposition", *Condensed Matter News*, Vol. 3, No. 4, 1994, p. IX, *Integrated Ferroelectrics*, Vol. 5, pp. 97-102, 1994.

L. D. McMillan, M. Huffman, T. L. Roberts, M. C. Scott, and C. A. Paz de Araujo, "Deposition of $Ba_{1-X}Sr_XTiO_3$ and $SrTiO_3$ via Liquid Source CVD (LSCVD) for ULSI DRAMS", *Integrated Ferroelectrics*, 1994, Vol. 4, pp. 319-324.

D. Chen, M. Azuma, L. D. McMillan, and C. A. Paz de Araujo, "A Simple Unified Analytic Model for Ferroelectric Thin Film Capacitor and Its Application for Nonvolatile Memory Operation", presented at *The Ninth International Symposium on the Applications of Ferroelectrics*, University Park, PA, August 7-10, 1994.

B. M. Melnick, M. C. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Characterization of a Spin-On 70/30 BST Process", abstract presented *at 6th International Symposium on Integrated Ferroelectrics*, Monterey, CA, March 14, 15, 16, 1994.

T. Ito, S. Hiraide, H. Yoshimori, H. Watanabe, T. Mihara, C. A. Paz de Araujo, M. C. Scott, and L. D. McMillan, "Characteristics of Ultra Thin Y-1 For A 1V Non-volatile Memory", abstract presented at *6th International Symposium on Integrated Ferroelectrics*, Monterey, CA, March 14, 15, 16, 1994.

J. D. Cuchiaro, C. A. Paz de Araujo, B. M. Melnick, and L. D. McMillan, "The Effects of Bipolar Pulsed Fatiguing on the CV Characteristics of PZT and Y-1 Discrete Capacitors", abstract presented *at 6th International Symposium on Integrated Ferroelectrics*, Monterey, CA, March 14, 15, 16, 1994.

J. W. Gregory, C. A. Paz de Araujo, and L. D. McMillan, "The Effect of Thin Scaling on the Capacitance Versus Voltage Characteristic of a Ferroelectric Memory Cell", abstract presented at *6th International Symposium on Integrated Ferroelectrics*, Monterey, CA, March 14, 15, 16, 1994.

S. Hayashi, M. Huffman, M. Azuma, L. D. McMillan, C. A. Paz de Araujo, Y. Shimada, and T. Otsuki, "Growth and Electrical Properties of $Ba_{0.7}Sr_{0.3}TiO_3$ Thin Films by LSCVD on 6 Inch Wafers", abstract presented at *6th International Symposium on Integrated Ferroelectrics*, Monterey, CA, March 14, 15, 16, 1994.

M. Huffman, L. D. McMillan, and C. A. Paz de Araujo, "Ferroelectric Integration: Progress and Challenges", *6th International Symposium on Integrated Ferroelectrics*, Monterey, CA, March 14, 15, 16, 1994.

K. Arita, E. Fujii, Y. Shimada, Y. Uemota, M. Azuma, S. Hayashi, T. Nasu, A. Inoue, A. Matsuda, Y. Nagano, S. Ktasu, T. Otsuki, G. Kano, L. D. McMillan, and C. A. Paz de Araujo, "Applications of Ferroelectric Thin films to Si Devices", *The Institute of Electronics, Information and Communication Engineers*, E77-C, No. 3, March 1994.

M. Azuma, M. Huffman, S. Hayashi, M. C. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Device Characteristics of Fatigue Free Y1 Deposited by LSCVD", presented *at 6th International Symposium on Integrated Ferroelectrics,* Monterey, CA, March 14, 15, 16, 1994.

S. Hayashi, M. Huffman, M. Azuma, Y. Shimada, T. Otsuki, G. Kano, L. D. McMillan, and C. A. Paz de Araujo, "Gigabit-Scale DRAM Capacitor Technology with High Dielectric Constant Thin Films by a Novel Conformal Deposition Technique", *Symposium on VLSI Technology*, Honolulu, Hawaii, June 1994.

M. Huffman, L. D. McMillan, M. C. Scott, and C. A. Paz de Araujo, "Novel Liquid Source CVD Technique for Ferroelectric, High Dielectric Constant and Complex Oxide Thin Films", presented at *9th International Symposium on the Applications of Ferroelectrics*, University Park, PA, August, 1994.

C. A. Paz de Araujo, J. W. Gregory, M. Huffman, J. D. Cuchiaro, J. McNelis, L. D. McMillan, and J. F. Scott, "Device Physics of Ferroelectric Storage Cells", invited talk presented at *the 2nd Pacific Rim Conference on Ferroelectric Applications,* Melbourne, Australia, November, 1994.

M. Huffman, C. A. Paz de Araujo, L. D. McMillan, J. D. Cuchiaro, M. C. Scott, and C. Echer, "Layered Perovskites and Their Applications in Ferroelectric Memories: Microstructural Compositional and Electrical Characterization of Y1-type Ferroelectric Films", presented at *1994 Fall Meeting of Materials Research Society,* Boston, MA, November 1994.

J. F. Scott, B. M. Melnick, J. D. Cuchiaro, R. Zuleeg, C. A. Paz de Araujo, L. D. McMillan, and M. C. Scott, "Negative Differential Resistivity in Ferroelectric Thin-Film Current-Voltage Relationships", *Journal of Integrated Ferroelectrics*, Vol. 4, pp. 85-92, 1994.

S. Hayashi, M. Azuma, Y Uemoto, Y. Shimada, T. Otsuki, M. Huffman, M. C. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Preparation and Characterization of Ferroelectric Thin Films by LSMCVD", presented at *1994 Fall Meeting of Materials Research Society*, Boston, MA, November, 1994.

S. Hayashi, Y. Uemoto, Y. Shimada, M. Azuma, T. Otsuki, M. Huffman, L. D. McMillan and C. A. Paz de Araujo, "Preparation and Characterization of Ferroelectric Thin Films by LSMCVD", presented at *The Japan Society of Applied Physics Fall Meeting*, Nagoya, Japan, September, 1994.

B. M. Melnick, M. C. Scott, C. A. Paz de Araujo, and L. D. McMillan, "Anomalous Fatigue Behavior in Zn Doped PZT", *Condensed Matter News*, Vol. 3, No. 1, 1994, pp. XI-XII.

D. Y. Chen, J. W. Gregory, T. S. Kalkur, C. A. Paz de Araujo, L. D. McMillan, and T. A. Rabson, "Modeling of Metal-Ferroelectric Semiconductor Field Effect Transistor Subthreshold Current", *Integrated Ferroelectrics*, Vol. 5, pp. 265-274, 1994.

Y. Shimada, Y. Nagano, E. Fujii, M. Azuma, Y. Eumoto, T. Sumi, Y. Judai, S. Hayashi, N. Moriwaki, J. Nakane, T. Otsuki, C. A. Paz de Araujo, and L. D. McMillan, "Integration Technology of Ferroelectrics and the Performance of the Integrated Ferroelectrics", *Integrated Ferroelectrics*, Vol. 11, pp 229-245, 1995.

T. Sumi, N. Moriwaki, g. Nakane, T. Nakakuma, Y. Judai, Y. Uemoto, Y. Nagano, S. Hayashi, M. Azuma, t. Otsuki, G. Kano, J. D. Cuchiaro, M. C. Scott, L. D. McMillan, and C. A. Paz de Araujo, "256Kb Ferroelectric Nonvolatile Memory Technology for 1T/1C Cell with 100ns Read/Write Time at 3V", *Integrated Ferroelectrics*, Vol. 6, pp. 1-13, 1995.

J. F. Scott, D. Galt, J. C. Price, J. A. Beall, F. H. Ono, C. A. Paz de Araujo, and L. D. McMillan, "A Model of Voltage-Dependent Dielectric Losses for Ferroelectric MMIC Devices", *Integrated Ferroelectrics*, Vol. 6, pp. 189-203, 1995.

J. W. Gregory, J. D. Cuchiaro, C. A. Paz de Araujo, and L. D. McMillan, "The Effect of Thin Film Scaling on the Capacitance Versus Voltage Characteristic of a Ferroelectric Memory Cell", *Integrated Ferroelectrics*, Vol. 6, pp. 281-288, 1995.

C. A. Paz de Araujo, J. D. Cuchiaro, L. D. McMillan, M. C. Scott, and J. F. Scott, "Fatigue-free Ferroelectric Capacitors with Platinum Electrodes", *Nature*, Vol. 374, 13 April 1995, pp. 627-629.

T. Otsuki, T. Sumi, E. Fujii, Y. Judai, Y. Shimada, N. Moriwaki, Y. Uemoto, M. Azuma, S. Hayashi, Y. Oishi, K. Arita, A. Inoue, T. Nagano, L.D. McMillan, and C. A. Paz de Araujo, "Ferroelectric Thin Film and Integration Technology", *95 MOCVD WORKSHOP*, Silicon Processing 1995, Kyungiu, Korea.

J. F. Scott, C. a. Paz de Araujo, and L. D. McMillan, "Ferroelectric Thin Films and thin Film Devices," *Ferroelectric Ceramics*.

N. Soyama, H. Uchida, K. Kageyama, K. Ogi, M. C. Scott, J. D. Cuchiaro, G. F. Derbenwick, L. D. McMillan, and C. A. Paz de Araujo, "Preparation of Self-Patterned SrBi2 Ta2 O9 thin Films From Photo-Sensitive Solutions", Symposium Proceedings Vol. 433, *Ferroelectric Thin Films*, Materials Research Society, 1966.

C.A. Paz de Araujo, J. Cuchiaro, V. Joshi, A. DeVilbiss, L.D. McMillan, and M. Azuma, "Characterization and Optimization of Am-1Bi2(Ta1-xNbx)mO3m+3 Layered Perovskytes Using Rayleigh's Analysis", ISIF 1996.

C. A. Paz de Araujo, B. M. Melnick, and L. D. McMillan, "The Impact of Space Charge on the Measurement of the Dielectric Constant Using the C-V Method in Ferroelectric Memories", abstract.

T. Mihara, C. A. Paz de Araujo, J. D. Cuchiaro, H. Watanabe, and L. D. McMillan, "Feasibility for Memory Devices and Electrical Characterization of Newly Developed Fatigue Eliminated Ferroelectric Capacitors".

F. M. Ross, K. M. Krishnan, N. Thangaraj, R. F. C. Farrow, R. F. Marks, A. Cebollada, S. S. P. Parking, M. F. Toney, M. Huffman, C. A. Paz de Araujo, L. D. McMillan, J. Cuchiaro, M. C. Scott, C. Echer, F. Ponce, M. A. O'Keefer, and C. Nelson, "Applications of Electrical Microscopy to Industrial Research", from *MRS Bulletin.*

K. Arita, Y. Shimada, Y. Uemoto, S. Hayashi, M. Azuma, Y. Judai, T. Sumi, E. Fujii, T. Otsuki, L.D. McMillan, and C.A. Paz de Araujo, "Ferroelectric Nonvolatile Memory Technology with Bismuth Layer-Structured Ferroelectric Materials", *Proceedings of Tenth IEEE International Symposium on Applications of Ferroelectrics,* Vol. 1, pp 13-16, August 1996.

E. Fujii, T. Otsuki, Y. Shimada, M. Azuma, Y. Uemoto, Y. Oishi, S. Hayashi, T. Sumi, Y. Judai, N. Moriwaki, J. Nakane, C. A. Paz de Araujo, G. F. Derbenwick, and L. D. McMillan, "Integration Technology of Ferroelectric Thin Films and Its Application to Si Devices", presentation for *ISIF,* 1996.

M. Azuma, T. Nasu, M. Kibe, Y. Uemoto, A. Inoue, Y. Shimada, E. Fujii, T. Otsuki, G. Kano, M. Scott, L. D. McMillan, and C. A. Paz de Araujo, "Optimized c-axis Oriented Strontium Bismuth Tantalate Grown from Metal Organic Deposition (MOD) Solutions" presentation for *ISIF,* 1996.

N. Solayappan, L. D. McMillan, C. A. Paz de Araujo, and B. Grant, "Second Generation Liquid Source Misted Chemical Deposition (LSMCD) Technology for Ferroelectric Thin Films", *Integrated Ferroelectrics,* Vol. 18, pp. 127-136, 1997.

H. Uchida, N. Soyama, K. Kageyama, K. Ogi, M. Scott, J. D. Cuchiaro, L. D. McMillan, and C. A. Paz de Araujo, "Characterization of Self-Patterned SBT/SBNT Thin Films from Photo-Sensitive Solutions", *Integrated Ferroelectrics, Vol. 18, pp 249-261,* 1997.

H. Uchida, N. Soyama, K. Kageyama, K. Ogi, M. C. Scott, J. D. Cuchiaro, G. F. Derbenwick, L. D. McMillan, and C. A. Paz de Araujo, "Characterization of Self-Patterned SrBi2Ta2O9 Thin Films From Photo-Sensitive Solutions", *Integrated Ferroelectrics, Vol. 16, pp 41-52,* 1997.

G. Fujii, T. Otsuki, Y. Judai, Y. Shimada, M. Azuma, Y. Uemoto, Y. Nagano, T. Nasu, Y. Izutsu, A. Matsuda, K. Nakao, K. Tanaka, K. Hirano, T. Ito, T. Mikawa, T. Kutsunai, L. D. McMillan, and C. A. Paz de Araujo, "Highly-Reliable Ferroelectric Memory Technology with Bismuth-Layer Structured Thin Films (Y-1 Family), *IEEE,* 1997.

N. Solayappan, G. F. Derbenwick, L. D. McMillan, and C. A. Paz de Araujo, "Conformal LSMCD Deposition of $SrBi_2(Ta_{1-x}Nb_x)_2O_9$, *Integrated Ferroelectrics,* Vol. 14, pp. 237-246, 1997.

H. Uchida, T. Atauki, N. Soyama, K. Kageyama, K. Ogi, J. D. Cuchiaro, L. D. McMillan, and C. A. Paz de Araujo, "Evaluation of SrBi2.2(Nb X Ta1 -)2.0o9.0 Capacitors Fabricated by Self-Patterning Process", *1998 ISIF.*

N. Solayappan, V. Joshi, A. D. DeVilbiss, J. Bacon, J. D. Cuchiaro, L. D. McMillan, and C. A. Paz de Araujo, "Chemical Solution Deposition (CSD) and Characterization of Ferroelectric and Dielectric Thin Films", *Integrated Ferroelectrics 22 (1998) 521.*

Patents (Issued and Pending)

Patent No: 3,986,897 Issued: Oct. 19, 1976
Aluminum Treatment to Prevent Hillocking

Patent No: 4,279,947 Issued: Jul. 21, 1981
Deposition of Silicon Nitride

Patent No: 4,707,897 Issued: Nov. 24, 1987
Monolithic Semiconductor Integrated Circuit Ferroelectric Memory Device and Methods of Fabricating and Utilizing Same

Patent No: 4,713,157 Issued: Dec. 15, 1987
Combined Integrated Circuit/Ferroelectric Memory Device, and Ion Beam Methods of Constructing Same

Patent No: 5,024,964 Issued: Jun. 18, 1991
Method of Making Ferroelectric Memory Devices

Patent No: 5,119,760 Issued: Jun. 9, 1992
Methods and Apparatus for Material Deposition

Patent No: 5,138,520 Issued: Aug. 11, 1992
Methods and Apparatus for Material Deposition

Patent No: 5,214,300 Issued: May 25, 1993
Monolithic Semiconductor Integrated Circuit Ferroelectric Memory Device

Patent No: 5,316,579 Issued: May 31, 1994
Apparatus for Forming a Thin Film With a Mist Forming Means

Patent No: 5,406,510 Issued: Apr. 11, 1995
Non-Volatile Memory

Patent No: 5,423,285 Issued: Jun 13, 1995
Process for Fabricating Materials for Ferroelectric, High Dielectric Constant, and Integrated Circuit Applications

Patent No: 5,434,102 Issued: Jul. 18, 1995
Process for Fabricating Layered Superlattice Materials and Making Electronic Devices Including Same.

Patent No: 5,439,845 Issued: Aug. 8, 1995
Process for Fabricating Layered Superlattice Materials and Making Electronic Devices Including Same

Patent No: 5,444,290 Issued: Aug. 22, 1995
Method and Apparatus for Programming Antifuse Elements Using Combined AC and DC Electric Fields

Patent No: 5,446,629 Issued: Nov. 14, 1995

Process for Fabricating Ferroelectric Integrated Circuit

Patent No: 5,456,945 Issued: Oct. 10, 1995
Method and Apparatus for Material Deposition

Patent No: 5,463,244 Issued: Oct. 31, 1995
Antifuse Programmable Element using Ferroelectric Material

Patent No: 5,466,629 Issued: Nov. 14, 1995
Process For Fabricating Ferroelectric Integrated Circuit

Patent No: 5,486,679 Issued: Nov. 21, 1995
Process for Fabricating Materials for Ferroelectric, High Dielectric Constant, and Integrated Circuit Applications

Patent No: 5,468,684 Issued: Nov. 21, 1995
Integrated Circuit with Layered Superlattice Material and Method of Fabricating Same

Patent No: 5,487,032 Issued: Jan. 23, 1996
Method and Apparatus for Reduced Fatigue in Ferroelectric Memory Elements

Patent No: 5,508,954 Issued: Apr. 16, 1996
Method and Apparatus for Reduced Fatigue in Ferroelectric Memory

Patent No: 5,514,822 Issued: May 7, 1996
Precursors and Processes for Making Metal Oxides

Patent No: 5,519,234 Issued: May 21, 1996
Ferroelectric Dielectric Memory Cell Can Switch at Least Giga Cycles and Has Low Fatigue – Has High Dielectric Constant and Low Leakage Current

Patent No: 5,523,964 Issued: June 4, 1996
Ferroelectric Non-Volatile Memory Unit

Patent No: 5,540,772 Issued: Jul. 30, 1996
Misted Deposition Apparatus for Fabricating an Integrated Circuit

Patent No: 5,541,870 Issued: Jul. 30, 1996
Ferroelectric Memory and Non-Volatile Memory Cell for Same

Patent No: 5,559,260 Issued: Sept. 24, 1996
Precursors and Processes for Making Metal Oxides

Patent No: 5,559,733 Issued: Sept. 24, 1996
Memory with Ferroelectric Capacitor Connectable to Transistor Gate

Patent No: 5,561,307 Issued: Oct. 1, 1996
Ferroelectric Integrated Circuit

Patent No: EP 0665 814 B1 Issued: Jan. 15, 1997
Precursors and Processes for Making Metal Oxides

Patent No: 5,612,082 Issued: Mar. 18, 1997
Process for Making Metal Oxides

Patent No: 5,614,252 Issued: Mar. 25, 1997
Method of Fabricating Barium Strontium Titanate

Patent No: 5,654,456 Issued: Aug. 5, 1997
Precursors and Processes for Making Metal Oxides

Patent No: 5,688,565 Issued: Nov. 18, 1997
Misted Deposition Method of Fabricating Layered Superlattice Materials

Patent No: 5,699,035 Issued: Dec. 16, 1997
ZNO Thin-Film Varistors and Method of Making the Same

Patent No: 5,719,416 Issued: Feb. 17, 1998
Integrated Circuit with Layered Superlattice Material Compound

Patent No: 5,723,171 Issued: Mar. 3, 1998
Integrated Circuit Electrode Structure and Process for Fabricating Same

Patent No: 5,759,923 Issued: Jun. 2, 1998
Method and Apparatus for Fabricating Silicon Dioxide and Silicon Glass Layers in Integrated Circuits

Patent No: 5,784,310 Issued: Jul. 21, 1998
Low Imprint Ferroelectric Material for Long Retention Memory and Method of Making the Same

Patent No: 5,788,757 Issued: Aug. 4, 1998
Composition and Process Using Ester Solvents for Fabricating Metal Oxide Films and Electronic Devices Including the Same

Patent No: 5,803,961 Issued: Sep. 8, 1998
Integrated Circuits Having Mixed Layered Superlattice Materials and Precursor Solutions for Use in a Process of Making Same

Patent No: 5,811,847 Issued: Sep. 22, 1998

PSZT for Integrated Circuit Applications

Patent No: 5,825,057 Issued: Oct. 20, 1998
Superlattice Materials and Making Electronic Devices Including Same

Patent No: 5,840,110 Issued: Nov. 24, 1998
Integrated Circuits Having Mixed Layered Superlattice Materials and Precursor Solutions for Use in a Process of Making the Same

Patent No: 5,843,516 Issued: Dec. 1, 1998
Liquid Source Formation of Thin Films Using Hexamethyl-Disilazane

Patent No: 5,846,597 Issued: Dec. 8, 1998
Liquid Source Formation of Thin Films Using Hexamethyl-Disilazane

Patent No: 2860505 Issued: Dec. 11, 1998
Apparatus for Depositing Materials

Patent No: 5,849,071 Issued: Dec. 15, 1998
Liquid Source Formation of Thin Films Using Hexamethyl-Disilazane

Patent No: 5,871,853 Issued: Feb. 16, 1999
UV Radiation Process for making Electronic Devices Having Low-Leakage-Current and Low-Polarization Fatigue

Patent No: 5,883,828 Issued Mar. 16, 1999
Low Imprint Ferroelectric Material for Long Retention Memory and Method of Making the Same

Patent No: 5,888,583 Issued Mar. 30, 1999
Misted Deposition Method of Fabricating Integrated Circuits

Patent No: 5,909,042 Issued Jun. 1, 1999
Electrical Component Having Low-Leakage Current and Low Polarization Fatigue Made by UV Radiation Process

Patent No: 5,932,295 Issued Aug. 3, 1999
Method and Apparatus for Misted Liquid Source Deposition of Thin Films with Increased Yield